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Agroforestry policy options for Nigeria: A simulation study

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Abstract

It is the general consensus among planners charged with the responsibility of Nigeria's development that the future growth of the country is closely linked to its agricultural development through the introduction and use of relevant improved technology, such as agroforestry. Currently, the level of technology usage in the agricultural sector is still very low, due to poor adoption of innovations. The situation suggests the need for an in-dept analysis of adoption of agroforestry-based technologies to determine the socio-economic characteristics of farmers that influence their adoption behaviours and perhaps to design policies which impact positively on agroforestry adoption through favourable policy recommendation and formulations. For the two-stage sampling technique used, structured questionnaire were designed and administered on 200 randomly selected farmers from four purposely selected local government area of Oyo State Nigeria, at the average of 50 farmers per local government. The data collected was analysed using Tobit. Adoption behaviour in the study area was found to be positive and significantly related to farm income, amount of credit available to the farmers and cultivated farm size. A negative and significant relationship was found to exist between the adoption of agroforestry-based technologies and frequency of extension visits and cooperative membership. The effect of different policy options on adoption of agroforestry-based technologies was also estimated. Stronger and closer ties among bodies involved in agroforestry and afforestation programmes with a view to creating more awareness by farmers and expanded agricultural credit scheme to enable farmers to adopt agroforestry-based technologies are recommended.

Key words: Agroforestry, adoption, Tobit, policy, Nigeria.

Introduction

An essential feature of the Nigerian agricultural scene is that small farm with land holdings of less than 2.0 hectares per farmer collectively produce over ninety percent of the total agricultural production in the country [8]. Majority of these farmers still produce at subsistence level using old management practices like shifting cultivation. However, due to various socio-economic factors, particularly rapid population growth, these traditional systems may no longer be practicable.

New production technologies are discovered by the day. Farmers because of a number of reasons are either adopting or not adopting these new production technologies. The adoption process involves taking decisions about alternatives. The decision by a farmer to use a particular innovation is a practical evidence of its adoption.

To meet the ever-increasing demand for food however, more land must be brought under cultivation. The development of technologies for increasing food production through increase in land productivity using highly productive farming techniques that are ecologically sound, economically viable and culturally acceptable gave birth to the concept of agroforestry. Agroforestry is a collective name for land use systems and technologies where woody perennial (trees, shrubs, palms, bamboos etc.) are deliberately used on the same land management units as agricultural crops and/or animals in some form of special arrangement [17]. The impact of agroforestry programmes has not been too noticeable in Nigeria [2].

This study seeks to identify the socio-economic characteristics of farmers that influence their adoption behaviour and perhaps design policies which impact positively on agroforestry adoption through favourable policy recommendation and formulations. This will shed more light on the problem of technology adoption and consequently the food productivity per farmer through agroforestry. The aim is to improve the participation level of farmers in agroforestry. This study will therefore fill the gap of previous studies, especially in Nigeria.

A great deal of research has been done on the diffusion and adoption of innovations. However, only few of these studies were on Nigeria. Daramola [6] studied the adoption of improved food production technology in Oyo State, Nigeria employing the Probit Model. The multivariate Probit Model employed in the analysis postulated the probability of a given farmer adopting the improved food production technology as a function of some socio-economic variables. Under the linearity assumption, his model gave satisfactory result on relationship between adoption decisions and his independent variables; he identified some factors influencing adoption decision. These factors include distance of input source, distance of the market, availability of credit, household size and farm income. Distance of the market and farm size even though not predicted *a priori,* showed positive influence while extension visits and cooperative membership had negative coefficient.

Adesina and Zinnah [3] and Adesina and Baydu-Forson [4] studied the technology characteristics, farmers' perceptions and adoption decisions where they attempted to test the hypothesis that farmers' perceptions of technology-specific characteristics significantly condition technology adoption decisions. The result of the study, however, showed that farmers perceptions of the technology-specific attributes of the varieties used are the major factors determining adoption and use intensities. Adesina [5] found out that the major factors that positively influence farmers' use and adoption of fertilizers in rice fields are cultivation of lowlands, use of mechanization, farm size, land pressure and availability of non-farm income. Factors found to negatively affect the use of fertilizer in rice fields are the distance of the field to the village, distance of the village to the major market and sex of the grower.

This paper intends to address the issues of the adoption of agroforestry-based technologies, to identify the socio-economic characteristics of farmers that influence their adoption behaviours using Tobit and design policies which impact positively on agroforestry adoption through favourable policy recommendation and formulations.

Materials and Methods

The study area and the data: The study area is Oyo State. The choice of the study area is informed by the location of International Institute of Tropical Agriculture (IITA) - an agricultural organisation that has been involved in alley cropping since early 1980s [9, 10, 12] and by the volume of extension work carried out in the area for Taungya [1].

A cross sectional sample survey of two hundred randomly chosen farmers from four purposively selected local government areas of Oyo State were studied. Fifty respondents/farmers were sampled per LGA. This two-stage sampling is necessary because of the need to balance probability with non-probability sample. The first stage of purposive sampling of four LGA where IITA had previously worked on agroforestry is to prevent exclusion of representative samples. The second stage involving random sampling of two hundred farmers (fifty per LGA) were studied. This is to give every farmer in the local government the opportunity of being selected.

The primary data used for this study were obtained from field survey where farm level data, on the socio-economic circumstances of the farmers and their farm management practices were collected. For this purpose a well-structured questionnaire was designed, developed and administered after validation.

The analytical model: For the analysis, Tobit model was used. This model has found several empirical applications in the adoption literature [3-5, 13, 16]. It tells whether adoption has taken place or not and the level of adoption if adoption has taken place at all. The model framework using an index function approach is:

$$I_i^* = \beta^T X_i + e_i \;\; ; \; Y_i = O \text{ if } I_i^* < T \;\; ; \; Y_i = I_i^* \text{ if } I_i^* > T$$

where Y_i= limited dependent variable, I_i^* = latent variable that indexes adoption, T= observed threshold level, X_i =vector of independent variables $X_1, X_2 \ldots\ldots X_{12}$, β = vector of parameter to be estimated, e_i =error term. Probability of adoption and intensity of use of technology is the dependent variable. X_i represents the independent variables in the model, where: X_1 stands for age, X_2 represent farm size, X_3 stands for household, X_4 represents distance of input source, X_5 stands for availability of credit, X_6 represents role of extension agents, X_7 stands for cooperative membership, X_8 stands for distance of product market, X_9 represents farm income, X_{10} stands for off farm income, X_{11} represent farmers' education, X_{12} stands for tenural status. Following Tobit decomposition framework suggested by McDonald and Moffit [11], the effects of changes of the socioeconomic characteristics on adoption probabilities and use intensities can be obtained.

Let the expected value of the dependent variable probability of adoption and intensity of use across all observations be represented as E(P), the expected value of the dependent variable conditional farmers adoption being above the threshold limit (i.e. already an adopter and thus now concerned about use intensities) be given as E(p), and the probability of the farmer being above the limit (i.e. the probability of adoption) be represented as F(z), where $z = X\beta/\sigma$.

The relationship between these variables can be shown to be:

$$E(P) = F(z) * E(p) \qquad \text{Eq. 1}$$

For a given change in the level of the socio-economic characteristics in the adoption of agroforestry based technologies, the effects on farmer adoption behaviour can be broken down into two parts by differentiating equation with respect to the socio-economic characteristics

Multiplying through by Xi/E(P), the relation in equation 2 can be converted into elasticity forms:

$$\delta E(P)/\delta Xi = F(z)\,[\delta E(p)/\delta Xi] + E(p)\,[\delta F(z)/\delta Xi] \qquad \text{Eq.2}$$

Re-arranging (Eq. 3) by using equation 1:

$$[\delta E(P)/\delta Xi]Xi/E(P) = F(z)\,[\delta E(p)/\delta Xi]\,Xi/E(P) + E(p)\,[\delta F(z)/\delta Xi]Xi/E(P) \qquad \text{Eq.3}$$

$$[\delta E(P)/\delta Xi]Xi/E(P) = [\delta E(p)/\delta Xi]\,Xi/E(p) + [\delta F(z)/\delta Xi]Xi/F(z) \qquad \text{Eq.4}$$

Results and Discussion

The analytical model presented above was empirically estimated using Shazam (Version 4.1). Shazam has the capability to estimate the total models and the generalized log likelihood function that were generated.

The average age of farmers studied was 49 years. The study revealed that only availability of credit to farmers is significant at 5% level of significance (Table 1). However, at 10% significance level, distance of input source from farm, membership of cooperative society and farmers' educational status were significant in explaining adoption decision and use intensities. Apart from age of farmer, farm size, household size, farmers' income and off-farm income, all the farmers' socio-economic characteristics were positively related to adoption decisions.

These results strongly confirm the maintained hypotheses that some farmers socio-economic characteristics determine observed adoption choices. For instance this study showed that age is negatively related to adoption. Studies have shown that younger farmers are more knowledgeable about new practices and may be more willing to bear risk due to their longer planning horizons [3, 14]. Following earlier empirical findings [6, 14], it is hypothesized that the sign on this variable is positive. In this study, however, cultivated farm size presented a negative sign. There is also no significant relationship between cultivated farm size and adoption of agroforestry-based technology in the study area.

The household size was hypothesized to have a positive sign in line with Daramola [6], but the coefficient came up with a negative sign, showing that the household size represented by all the people living under the same roof, which also represents the number of family labour, is negatively related to adoption. There was, however, no significant relationship between this factor and the adoption of agroforestry-based technologies.

The distance of input source hypothesized to have a negative sign came up with a positive sign as it was the case in Daramola [6]. The meaning of this is that the thinking that farmers will be

Table 1. Estimated results for farmers' adoption model using socio-economic variables.

Variable	Normalized coefficient	Asymptotic		Regression coefficient
		Standard error	T-ratio	
X_1 (AGE)	-0.83741E-03	0.57880E-02	-0.14468	-0.55789E-03
X_2 (FM SZ)	-0.10549E-01	0.25591E-01	-0.4123	-0.70281E-02
X_3 (HD SZ)	-0.11906E-01	0.20195E-01	-0.58952	-0.79316E-02
X_4 (DT IMP)	0.72918E-01	0.53802E-01	1.3553*	0.48579E-01
X_5 (CRDT)	0.22507	0.11105	2.0268**	0.14994
X_6 (EXT)	0.26229E-01	0.16609	0.15792	0.17474E-01
X_7 (COOP)	0.16116	0.11847	1.3604*	0.10737
X_8 (DT PRD)	0.10237E-01	0.50470E-01	0.20284	0.68203E-02
X_9 (FM IN)	-0.20110E-06	0.51254E-06	-0.39236	-0.13398E-06
X_{10} (OFF FM)	-0.15419E-06	0.85662E-06	-0.18000	-0.10272E-06
X_{11} (FM ED)	0.66641E-01	0.55003E-01	1.2116*	0.44397E-01
X_{12} (TEN STAT)	0.24726E-01	0.10453	0.23654	0.16473E-01
CONSTANT	1.0789	0.52222	2.0661**	0.71881
Y	1.5010	0.81393E-01	18.442	

The predicted probability of Y > Limit given average x (I) = 0.9744
The observed frequency of Y > Limit IS = 0.9050
At mean values of all X (I), E(Y); E(Y) = 1.3053
Log – Likelihood function = -208.47465
Mean – square error = 0.37265066
Mean error = -0.17136042E-01
Squared correlation between observed and expected values = 0.91052E-01
** Significant at 5%
* Significant at 10%

Table 2. Tobit total elasticity decompositions for changes in socio-economic characteristics.

Variable	Elasticity of adoption probability	Expected use intensity (Elasticity of E(Y))	Total elasticity	Approximate total elasticity
X_1 (AGE)	-0.199	-0.0197	-0.2187	-0.22
X_2 (FM SZ)	-0.0164	-0.0162	-0.0326	-0.03
X_3 (HD SZ)	-0.406	-0.0402	-0.4462	-0.45
X_4 (DT IMP)	0.1243	0.1229	0.2472	0.25
X_5 (CRDT)	0.1669	0.1651	0.332	0.33
X_6 (EXT)	0.0266	0.0263	0.0529	0.05
X_7 (COOP)	0.0964	0.0954	0.1918	0.19
X_8 (DT PRD)	0.0128	0.0126	0.0254	0.03
X_9 (FM IN)	-0.0088	-0.0087	-0.0175	-0.02
X_{10} (OFF FM)	-0.0021	-0.0021	-0.0042	-0.00
X_{11} (FM ED)	0.0632	0.0625	0.1257	0.13
X_{12} (TEN STAT)	0.0354	0.0350	0.0704	0.07

discouraged to adopt because of increased cost of adoption due to traveling is not correct. The study revealed a significant relationship between distance of input source and adoption of agroforestry-based technologies at 10% level of significance.

Credit availability came up with a positive sign as expected. Credit availability therefore has a positive effect on adoption behaviour of farmers in the study area. The level of credit available to a farmer is a measure of the farmer's worth in financial terms. Most farmers mention credit constraints as a major determinant in their adoption decisions. They obviously cannot adopt when their purchasing power is ineffective. Availability of credit is significant in explaining the adoption decision and use intensities of agroforestry-based technologies at 5% level of significance. Contact with extension agents as expected have a positive effect on adoption based upon the innovation–diffusion theory. Such contacts by exposing farmers to availability of information can be expected to stimulate adoption [14]. This trend is, however, not in agreement with Daramola [6] that reported a negative effect of extension activities on adoption. Contacts with extension agents are expected to expose farmers to availability of information which is expected to stimulate adoption. The result, however, shows no significant relationship between this factor and adoption of agroforestry-based technologies in the study area.

Cooperative membership came up with a positive sign. Cooperative membership of farmers therefore has a positive effect on their adoption behaviour. These variables as expected must have included some experience sharing which will influence the adoption behaviour of individual farmers as well as the whole group. There is significant relationship between this factor and adoption of agroforestry-based technologies in the study area at 10% level of significance.

The distance of product market from the farm was predicted to have a negative influence on adoption behaviour. Contrary to the hypothesis, the variable came up with a positive sign. It is either most farmers prefer to sell their products in far markets because it attracts a better price or most farmers are not disturbed by the distance of the product from the market. There is no significant relationship between this factor and adoption of agroforestry-based technologies in the study area.

Farmers income and off-farm income, hypothesized to have positive impact on adoption, came out with negative sign. This contradicts the believe that income has a very strong motivation as reported by Daramola [7] and Savadogo et al. [15]. A high off-farm income may suggest that farming is less lucrative, in which case the farmer is farming as either as a hobby or to meet subsistence needs. The farm income on the other hand may not be high enough to encourage the farmer to take some 'risk' and adopt. Hence the negative sign.

Educational level of the farmer is expected to be related to the ability of the farmer to obtain, process and use information relevant to adoption of agroforestry-based technologies. A positive relationship is hypothesized between this variable and adoption. This variable presented a positive sign as expected. The study revealed that farmer's level of education significantly affects his adoption of agroforestry-based technologies at 10% level of significance.

Tenant farmers may have been warned not to cultivate any perennial crop unlike land owners who can do so freely. It becomes easier for the landowners to adopt agroforestry-based technologies. This variable presented a positive sign as expected. Though there is a positive effect of tenural status on adoption of agroforestry-based technologies as revealed by the study, there is no significant relationship between this factor and adoption of agroforestry-based technologies in the study area.

The computed elasticity estimates in Table 2 show in elastic responses of adoption to changes in the socio-economic characteristics considered. Availability of credit has the highest impact on the

Table 3. Simulation results of variation in policy variables on elasticity of adoption probability.

Variables	Elasticity of adoption probability	+5%	%	+10%	%	+20%	%
X1 (AGE)	-0.20	-0.21	5	-0.22	10	-0.24	20
X5 (CRDT)	0.20	0.21	5	0.22	10	0.24	20
X6 (EXT)	0.03	0.03	0	0.03	0	0.04	33
X7 (COOP)	0.10	0.11	10	0.11	10	0.12	20
X11 (FM ED)	0.06	0.06	0	0.07	16.7	0.07	16.7
X12 (TEN STAT)	0.04	0.04	0	0.04	0	0.05	25

probability of adoption and use intensities. The total elasticity value for distance of input is next. Membership of cooperative society and farmers' education have almost similar effects on the total adoption elasticity and its components. Tenural status and role of extension agents have close effects on the total adoption elasticities.

The magnitude of change in the level of adoption of agroforestry-based technologies as a result of changes in government policies was obtained by performing simulation analysis on some identified variables that could be influenced by government policies (Tables 3-5). The simulation is done with an increase in values of the identified variables by 5, 10 and 20%.

The results revealed a kind of ranking among the policy variables treated. The elasticity of adoption will increase with rising level of role of extension agents with 33%, followed by tenural status with 25%, membership of cooperative societies and availability of credit to farmers with 20% and farmers' educational status with 16.7%. The age of farmers shows a negative response to adoption of agroforestry-based technology in the study area. The expected use intensity follows the same trend.

The implication of the foregoing analyses is that role of extension agents is the chief factor affecting the behaviour of farmers towards the adoption of agroforestry-based technologies in the study area. Other factors are: tenural status of farmers, availability of credit to farmers, membership of cooperative society, farmers' level of education and age of farmers. The age of farmers negatively affects their adoption behaviour. Younger farmers are more willing to adopt agroforestry-based technologies than the older rigid farmers in the study area.

The variables discussed above are some of the policy variables which can be used by policy makers to improve the current level of adoption of agroforestry-based technologies among farmers in Oyo State and the entire country Nigeria. Hence any policy that will improve the quality and/or coverage of extension work is likely to increase adoption of agroforestry-based technologies. Landowners are more likely to adopt agroforestry-based technologies than tenants. Any policy that provides land to prospective farmers is likely to increase adoption of agroforestry-based technologies. Policies in Nigeria that increase the amount of credit available to farmers or reduce the "bottlenecks" associated with credit acquisition will lead to an increase in adoption of agroforestry-based technologies. Policies that will attract people with higher levels of education into adopting agroforestry-based technologies and/or encourage illiterate farmers to undergo education/training would be expected to lead to increase in adoption of the technologies.

Summary and Conclusions

This study attempts to find out to what extent rural farmers are participating in the various agroforestry-based technologies and the factors that affect agroforestry adoption by farmers as well as how policy changes could be used to raise the current level of adoption of agroforestry-based technologies. The results of the empirical analysis revealed that only availability of credit to farmers has significant effect on adoption of agroforestry-based technology at 0.05 level. However, at 0.10 level of significance, distance of input source from farm, membership of cooperative society and farmers' educational status are significant in explaining adoption decision of farmers in the study area. Farmers' income is average of ₦10,000 per month and off-farm income about ₦8,000 per month on the average. Most farmers combine farming with other occupations. Apart from these factors and farm and household size, all the farmers' socio-economic characteristics are positively related to the adoption decision. The estimates from the computed elasticities show that marginal changes in the socio-economic characteristics of farmers increase the probability of adoption of agroforestry practices in the study area. The results of the simulation study revealed a kind of ranking among the policy variables treated. The elasticity of adoption will increase with rising level of role of extension agents with 33%, followed by tenural status with 25%, membership of cooperative societies and availability of credit to farmers with 20% and farmers' educational status with 16.7%. The age of farmers shows a negative response to adoption of agroforestry-based technology in the study area. The expected use intensity follows the same trend. The variables discussed above are some of the policy variables which can be used by policy makers to improve the current level of adoption of agroforestry-based technologies among farmers in Oyo State and Nigeria as a whole. Any policy that will improve the quality and/or coverage of these variables is likely to increase adoption of agroforestry-based technologies.

Table 4. Simulation results of variation in policy variables on expected use intensity.

Variables	Expected use intensity	+5%	%	+10%	%	+20%	%
X1 (AGE)	-0.02	-0.02	0	-0.02	0	-0.02	0
X5 (CRDT)	0.20	0.21	5	0.22	10	0.24	20
X6 (EXT)	0.03	0.03	0	0.03	0	0.04	33
X7 (COOP)	0.10	0.11	10	0.11	10	0.12	20
X11 (FM ED)	0.06	0.06	0	0.07	16.7	0.07	16.7
X12 (TEN STAT)	0.04	0.04	0	0.04	0	0.05	25

Table 5. Simulation results of variation in policy variable on total elasticity.

Variables	Total elasticity	+5%	%	+10%	%	+20%	%
X1 (AGE)	-0.22	-0.23	4.5	-0.24	9.1	-0.26	18.2
X5 (CRDT)	0.33	0.35	6.1	0.36	9.1	0.40	21.2
X6 (EXT)	0.05	0.05	0	0.06	20	0.06	20
X7 (COOP)	0.19	0.20	5.3	0.21	10.5	0.23	21.1
X11 (FM ED)	0.13	0.14	7.7	0.14	7.7	0.16	23.1
X12 (TEN STAT)	0.07	0.07	0	0.08	14.3	0.08	14.3

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